

# **Moon**



## **Lesson 2 – Rocketed to the Moon**

## Rocketed to the Moon

**Grade Level:** 7<sup>th</sup> – 12<sup>th</sup>

**Time needed:** 1 – 2 class periods

### Objectives:

- Determine and control variables
- Create graphical and written results
- Present results using whiteboards to peers
- Interpret results
- Identify examples of Newton's Laws as they relate to the experiment
- Compare conclusions to original hypotheses

### Arizona State Standards:

1SC-P2, P3, P6

5SC-P4-02, P5, P6, P7

2M-P1, P5, P6, D1

3M-P1, P2



### Abstract:

As well as being exciting for students, this lesson serves as an introduction to Newton's three Laws of Motion. Students will explore how these laws work using Alka-seltzer rockets. Students will make a hypothesis, conduct three experiments using different variables and controls, make observations, collect data, and compare and present results. This experiment is interdisciplinary, containing elements of physics, chemistry, and mathematics, therefore allowing students to integrate concepts learned in several subject areas. **This is a good experiment to introduce mechanical kinematics or dynamics.**

### Background:

In order to reach the Moon, we needed a propulsion system that created enough thrust to escape the gravitational pull of the Earth. The Apollo moon missions used the Saturn V **rocket**, designed by German scientist Wernher von Braun to propel the astronaut capsule into space. The Saturn V stood over 363 feet tall, taller than the Statue of Liberty, and weighed nearly 6 million pounds when fully loaded. 90% of this weight was fuel! When fired the rocket engines produced 1.5 million pounds of thrust while consuming 1,250 gallons of kerosene fuel per second and 2,083 gallons of liquid oxygen.

Today, rockets used on the space shuttle burn both liquid and solid fuels during launch and liquid fuel for maneuvers while in orbit. An oxidizer, which allows fuel to combust, must also be present in a rocket. The space shuttle's solid rocket fuel is aluminum and its oxidizer is ammonium perchlorate. Its liquid fuel is a mixture of liquid hydrogen and liquid oxygen.

Rockets work because they follow the natural laws of physics. Isaac Newton proposed three Laws of Motion, which are listed below. In this lesson students will explore Newton's Laws as

they relate to rocket propulsion by observing and interpreting the effects of changes in mass and propellant in model rockets made using film canisters and Alka-seltzer. Students will document the data they gather using tables and graphs and share results with their peers.

### **NEWTONS LAWS OF MOTION**

**First Law:** *An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.*

**Second Law:** *The acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object. In terms of an equation, the net force is equated to the product of the mass (m) times the acceleration (a).*

$$F_{\text{net}} = m \times a$$

**Third Law:** *For every action, there is an equal and opposite reaction.*

<b>Materials:</b>	Balance	
	Whiteboards	Straws
	Film canisters (with inside lid)	Tape measure
	Alka-seltzer tablets	Tape
	Stopwatch	Quarters
	Cold water	Markers
	Meter/yard stick	Safety goggles
	String	Towels
	Scissors	

#### **Instruction:**

Introduction – Students will conduct three experiments dealing with the motion of objects. Film canister rockets will be launched using Alka-seltzer and water as fuel. Depending on time limitations, either assign each group a different experiment or have each group perform all three experiments. Explain the different experiments. Take the first few minutes to discuss and write on the board the variables involved in these experiments. Ask the students to list them. These variables are:

**Amount of water**  
**Form of tablet**

**Amount of tablet**  
**Mass**

Write a question on the board for students to think about while conducting their experiments. Sample questions might include:

**How is your experiment similar/dissimilar to how rockets work?**  
**What are some other variables involved in the launch of real rockets?**  
**How can a rocket be made more efficient?**

Main Lesson – Divide students into small lab groups (3 to 5 students) and make sure they have all materials needed for the experiment(s) assigned to them. It may help to design a handout for each group with Newton's Laws. However, I like to keep this discussion for the grand finale!

### **Experiment 1: Fuels**

- Students will discuss and develop a hypothesis to try and answer the following question:

***Question: How much of each reactant (tablet and water) is needed to make your canister rocket go the farthest?***

- Students will write their hypothesis on the whiteboard. *For example: We think the rocket will travel farthest with  $\frac{1}{2}$  tablet of Alka-seltzer and  $\frac{1}{2}$  canister of water.*
- Pass out Student Sheet for Experiment 1.
- Decide if students will launch rockets vertically or horizontally. To horizontally launch canisters tape straw segments to the outside of the film canisters and have two students tightly hold the ends of a string about 16 feet long.
- Students will conduct an experiment on fuel ratios to test their hypothesis. First perform 3 sets of trials keeping the water amount constant and varying the amount of tablet. Then do 3 other sets of trials keeping the tablet amount constant and varying the amount of water. Record how far the rocket traveled for each test on the Student Sheet. Graph the results and answer the Experiment 1 questions.

### **Experiment 2: Mass (Payload)**

- Students will discuss and develop a hypothesis to try and answer the following question:

***Question: How does rocket mass affect the distance it travels?***

- Pass out Student Sheet for Experiment 2.
- Students will test their hypothesis by changing the mass of the rocket canister. Tape one or more quarters onto the canister and launch it keeping the amount of water and tablet constant (use  $\frac{1}{4}$  tablet and 2ml or  $\frac{1}{4}$  canister of water). Observe how varying mass affects the distance traveled by the rocket. Do 3 to 5 trials with different masses and record the results. Finally, graph the results and answer the Experiment 2 questions.

### **Experiment 3: Fuel Distribution**

- Students will discuss and develop a hypothesis to try and answer the following question:

***Question: How does the distribution of the tablet affect launch time and forward motion of the canister?***

- Pass out Student Sheet for Experiment 3.
- Students will design an experiment that tests reaction time till launch and how far the canister travels using  $\frac{1}{4}$  tablet in three forms whole, broken, and crushed. Make a data table, graph the results and answer the Experiment 3 questions.

Conclusion – Let this be a time of class discussion and questioning. If the students need a little help getting going start off with a pertinent question or comment (examples follow). Have each group present their results to the class. Make sure groups have included visual and written results and that they answer the questions on the Student Sheets.

Pass out Newton's Laws (you can make a copy from this lesson) and explain how Newton's Laws apply to this experiment.

Questions to help get the discussion started:

- What is the force in all your experiments?
- What propelled the canister?
- What happened when the form of the tablet was changed?
- What happened when you added mass to the canister?
- Why is the reaction faster when the tablet is broken?
- What is the action and reaction in your experiments?
- Why was there some tablet left in the canister after launch?
- What other forces are acting on your canister? ETC....

**Comments:** The following may help facilitate the lesson:

- Be a "guide on the side"
- Make sure students do enough trials to get accurate data
- The stopwatch is used to measure reaction time; more surface area results in faster reaction time
- When using the string attach the rocket to the string first and then fill the canister vertically, put the lid on and pull the string tight for launch
- Use a marker to designate launch position on string
- Each student should have a position or task while performing each experiment (i.e. stopwatch, tape measurer, launcher, recorder, etc)

**Assessment:** Performance and Formative assessment – when students are giving their presentations make sure they understand and explain concepts clearly. Assign an individual lab report to be turned in.

**Remediation:** Students with special needs will be paired with a peer/tutor to perform this lesson. Students can be given a study sheet with instructions included.

**Extension:** Build a rocket that launches in two stages and explain how and why it works.

**Vocabulary:** Rocket, payload, Newton's Laws of Motion

**References:**

- <http://spacelink.nasa.gov/products>
- <http://www.grc.nasa.gov>
- NASA, Rockets: A Teacher's Guide with Activities in Science, Mathematics, and Technology, EG-1999-06-108-HQ

**Additional Resources:**

- <http://www.reachoutmichigan.org/funexperiments/quick/hawaii/AlkaRocket.html>
- <http://www.physicsclassroom.com/Class/newtlaws/newtltoc.html>
- <http://hyperphysics.phy-astr.gsu.edu/hbase/newt.html>
- [http://www.genesismission.org/educate/scimodule/LaunchPropulsion/L&P\\_PDFs/B8\\_STnewtonslaws.pdf](http://www.genesismission.org/educate/scimodule/LaunchPropulsion/L&P_PDFs/B8_STnewtonslaws.pdf)
- [http://www.latech.edu/ideaplace/nerc/rockets/3-2-1\\_pop!.pdf](http://www.latech.edu/ideaplace/nerc/rockets/3-2-1_pop!.pdf)
- <http://www.grc.nasa.gov/WWW/K-12/airplane/bgp.html>

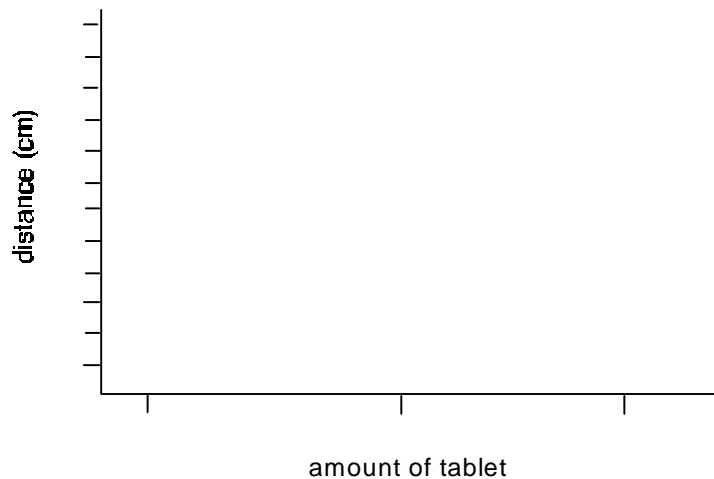
## Student Sheet for Experiment 1 – Fuels

Fill in the table, graph the results, and answer the questions.

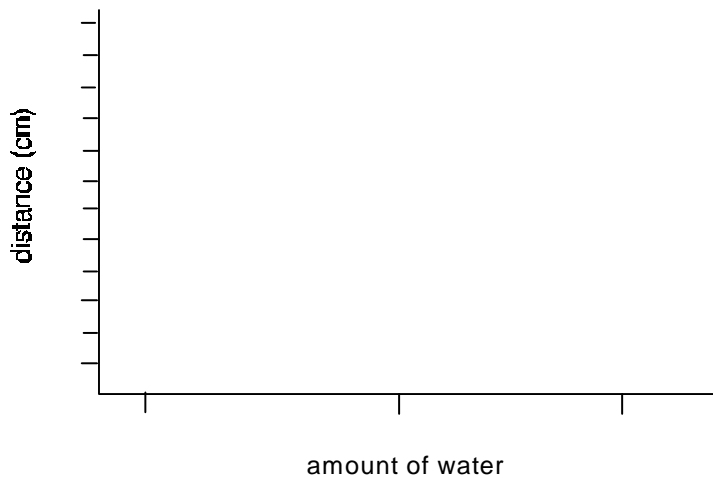
Amount of water	Amount of tablet	Distance traveled (cm)
<b>Keep amount of water constant for 3 different trials</b>		
$\frac{1}{2}$ full	$\frac{1}{4}$	
$\frac{1}{2}$ full	$\frac{1}{2}$	
$\frac{1}{2}$ full	$\frac{3}{4}$	
$\frac{1}{4}$ full	$\frac{1}{4}$	
$\frac{1}{4}$ full	$\frac{1}{2}$	
$\frac{1}{4}$ full	$\frac{3}{4}$	
$\frac{3}{4}$ full	$\frac{1}{4}$	
$\frac{3}{4}$ full	$\frac{1}{2}$	
$\frac{3}{4}$ full	$\frac{3}{4}$	
	<b>Keep amount of tablet constant for 3 different trials</b>	
$\frac{1}{4}$ full	$\frac{1}{4}$	
$\frac{1}{2}$ full	$\frac{1}{4}$	
$\frac{3}{4}$ full	$\frac{1}{4}$	
$\frac{1}{4}$ full	$\frac{1}{2}$	
$\frac{1}{2}$ full	$\frac{1}{2}$	
$\frac{3}{4}$ full	$\frac{1}{2}$	
$\frac{1}{4}$ full	$\frac{3}{4}$	
$\frac{1}{2}$ full	$\frac{3}{4}$	
$\frac{3}{4}$ full	$\frac{3}{4}$	

## Student Sheet for Experiment 1 – Fuels

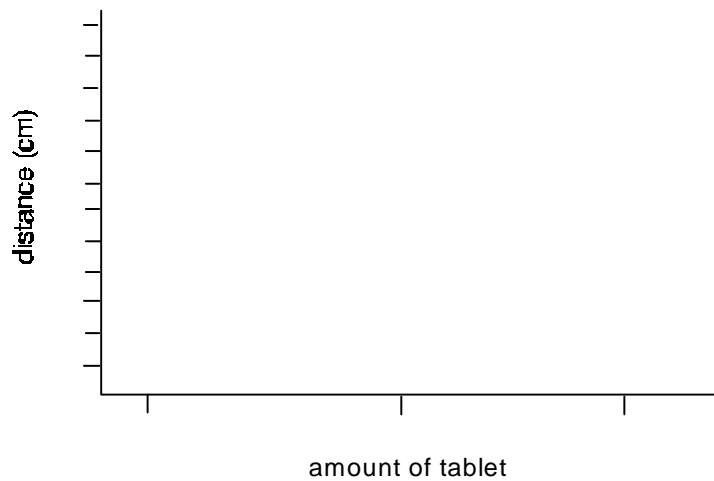
**1/4 Canister of Water**



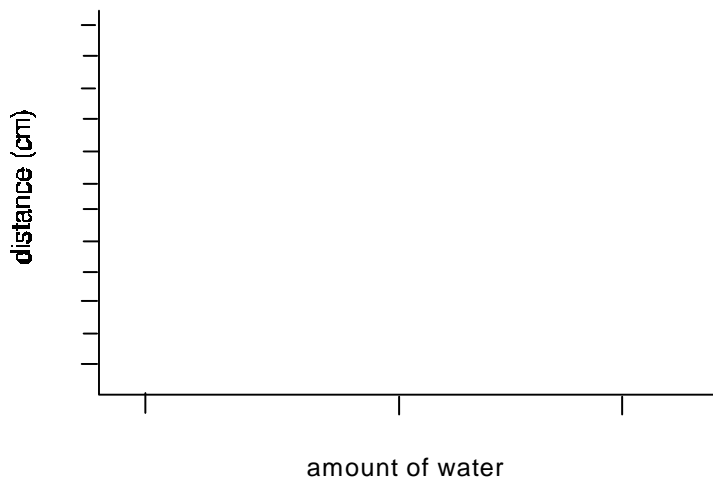
**1/4 Amount of Tablet**



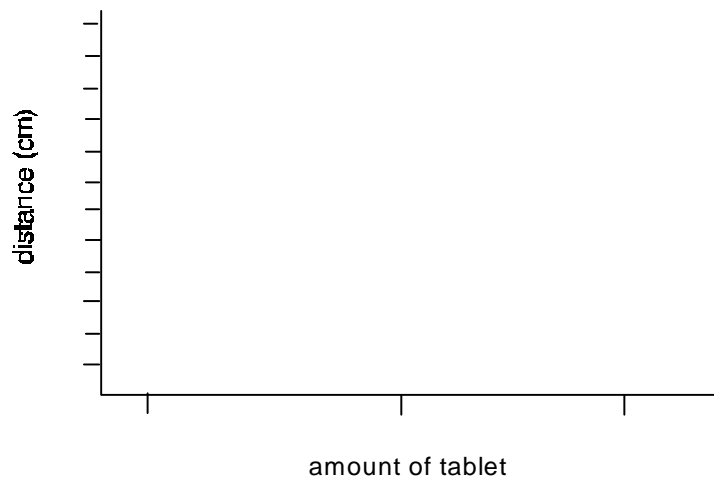
**1/2 Canister of Water**



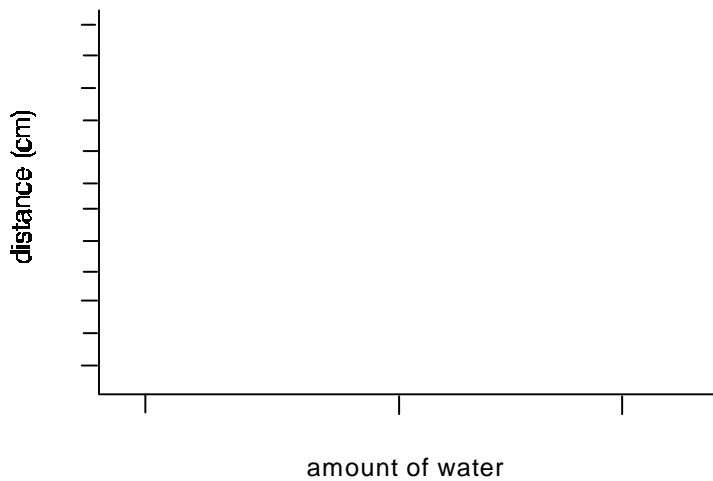
**1/2 Amount of Tablet**



**3/4 Canister of Water**



**3/4 Amount of Tablet**



## Questions for Experiment 1

1. Using your data and graphs, what amount of water and tablet made the canister travel farthest?
2. What are the two independent variables in this experiment?
3. What is the dependent variable?
4. Why might the canister travel farthest with these particular amounts of water and tablet?
5. Why does the canister lid pop off?
6. Which one of Newton's Laws explains why the canister moved forward?
7. Draw a sketch of what might be happening to the reactants inside the canister?

## Student Sheet for Experiment 2 – Mass (Payload)

Fill in the table and complete the graph below. Then answer the questions.

Amount of tablet	Amount of water	Number of quarters	Mass (g) of canister + quarters	Distance canister traveled
$\frac{1}{4}$	$\frac{1}{4}$ full	0		
$\frac{1}{4}$	$\frac{1}{4}$ full	1		
$\frac{1}{4}$	$\frac{1}{4}$ full	2		
$\frac{1}{4}$	$\frac{1}{4}$ full	3		
$\frac{1}{4}$	$\frac{1}{4}$ full	4		

Make a line graph of your results with distance on the vertical or y-axis and mass (g) on the horizontal or x-axis:



## Questions for Experiment 2

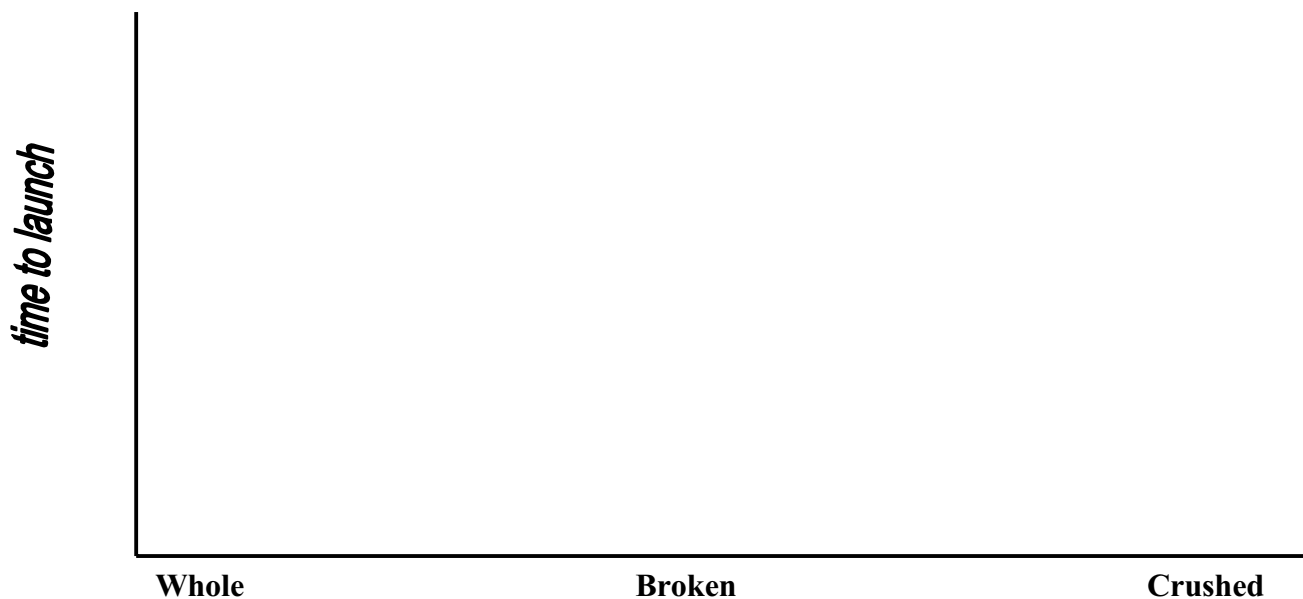
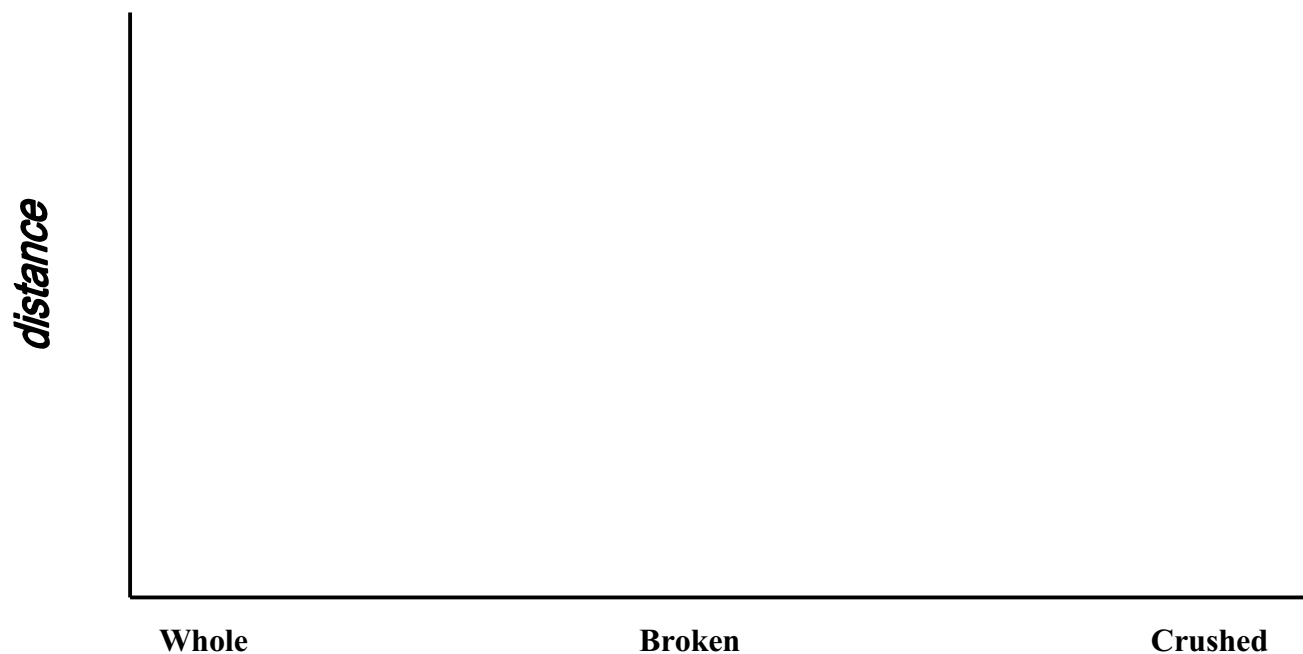
1. What happened when more mass was added to the canister? Explain.
2. How might the amount of **payload**, everything the rocket is carrying, affect the force needed, or the amount of fuel needed to launch the rocket safely into space?
3. How could more thrust be produced without using more fuel? Why wouldn't you just use more fuel?
4. Which one of Newton's Laws of Motion does this experiment explore?

### Student Sheet for Experiment 3 – Fuel Distribution

Fill in the table and complete the graphs below. Then answer the questions.

**How does the form of tablet affect distance and launch time**

Form of tablet	Water added	Distance canister traveled	Time it takes to launch
Whole	$\frac{1}{4}$ full		
Broken into pieces	$\frac{1}{4}$ full		
Crushed/powdered	$\frac{1}{4}$ full		



### **Questions for Experiment 3**

1. How does the form of the tablet affect the distance traveled?
2. How does the form of the tablet affect the time it takes for the canister to launch?
3. Why might the time to launch be different for different forms of the tablet?
4. How might the information learned from this experiment be applied to launching a real rocket?